

VI RESULTS OF NON-DESTRUCTIVE INSTRUMENTAL ANALYSIS.

XRF-, FTIR-SPECTROSCOPY AND MICROSCOPY

SCIENTIFIC ANALYSIS

Confronted with indications that the *SNML* could be a forgery, we reviewed data from our previous analyses again and supplemented it with additional readings. Again, we were short of time. During the first measurement campaign we employed X-ray fluorescence analysis to identify specific trace elements and thereby characterize different writing and drawing materials. In the new measurement campaign, we once again carried out an extensive X-ray fluorescence analysis. In addition, this time we also employed reflection infrared spectroscopy and confocal microscopy.

As with earlier measurement campaigns, we were determined not to take samples. Throughout the process, we have continued to regard the object in question as unique, and as such not to be physically altered in any way. Throughout the analysis, however, it has been clear that non-destructive testing provides less comprehensive results than methods that require testing physical samples. The examinations described below were carried out not only on the *SNML*, but also on reference objects. The most important of these in this framework was the *SN Graz*, which is generally accepted as authentic.

The following illustrates the results of the analysis in detail.

XRF-RESULTS

The printing inks

At an earlier date, we had performed XRF line-scans on both the *SNML* and the *SN Graz* to compare the elemental compositions of the printing ink and the paper. These measurements were performed at just a few selected sites.

Fig. 1: *SNML*, f. 9v: The starting point of the XRF scan (red cross).

Fig. 2: *SNML*, f. 9v: The end-point of the XRF scan (red cross).

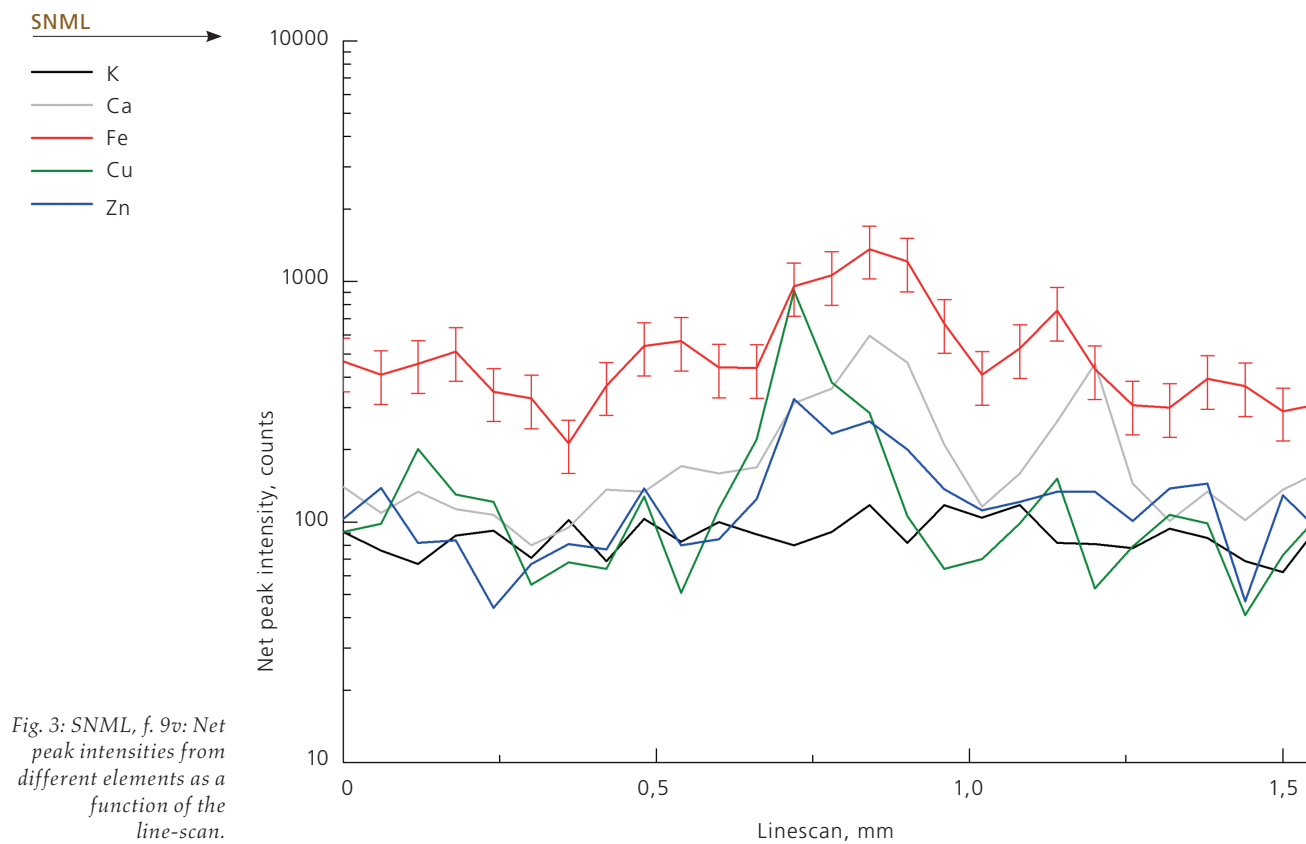
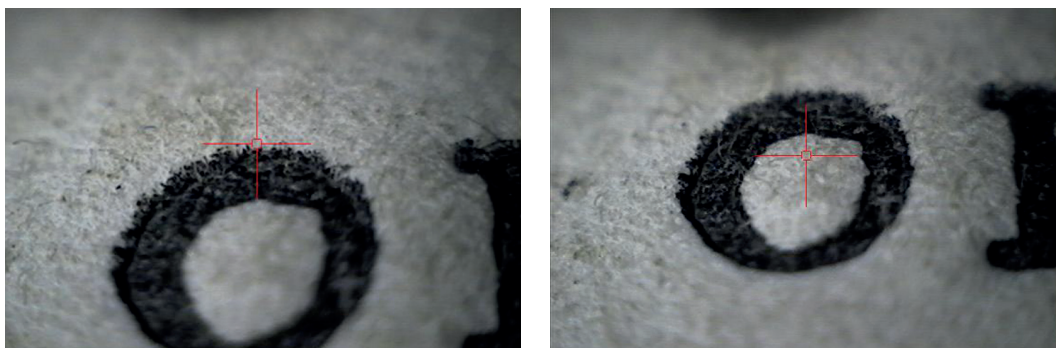


Fig. 3: *SNML*, f. 9v: Net peak intensities from different elements as a function of the line-scan.

The *SNML* printing ink clearly contains very slight traces of copper (Cu), iron (Fe), zinc (Zn) and calcium (Ca) (see Fig. 3). As we have mentioned before, paper and printing ink primarily contain “organic” materials. The mere presence of these elements therefore cannot be assessed as an indicator that the *SNML* was forged during the last few years or decades.

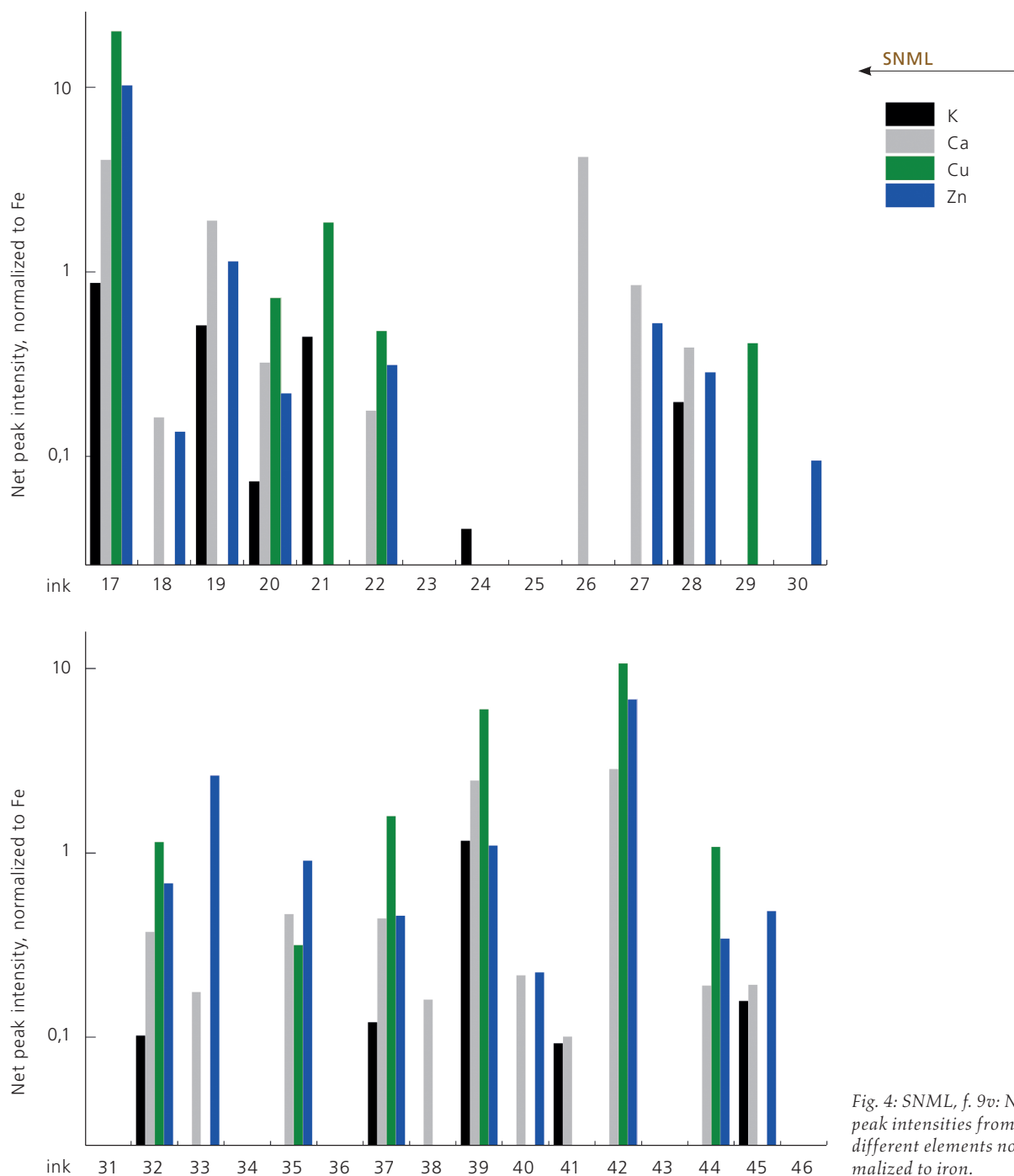


Fig. 4: *SNML*, f. 9v: Net peak intensities from different elements normalized to iron.

During our last campaign (10/2012) we measured the object at a number of different sites where we also found a variety of elements. In order to compare the amounts detected, we normalized these traces to the net peak intensity of iron. This compilation clarifies that the relative concentration of different trace elements is the underlying factor in a certain range of variation. We performed the same measurements on the Graz copy (SN Graz).

Compared to the *SNML*, the printing ink used in the SN Graz contains smaller amounts of trace elements.

Fig. 5: SN Graz, f. 9v: The starting point of the XRF scan (red cross).

Fig. 6: SN Graz, f. 9v: The end-point of the XRF scan (red cross).

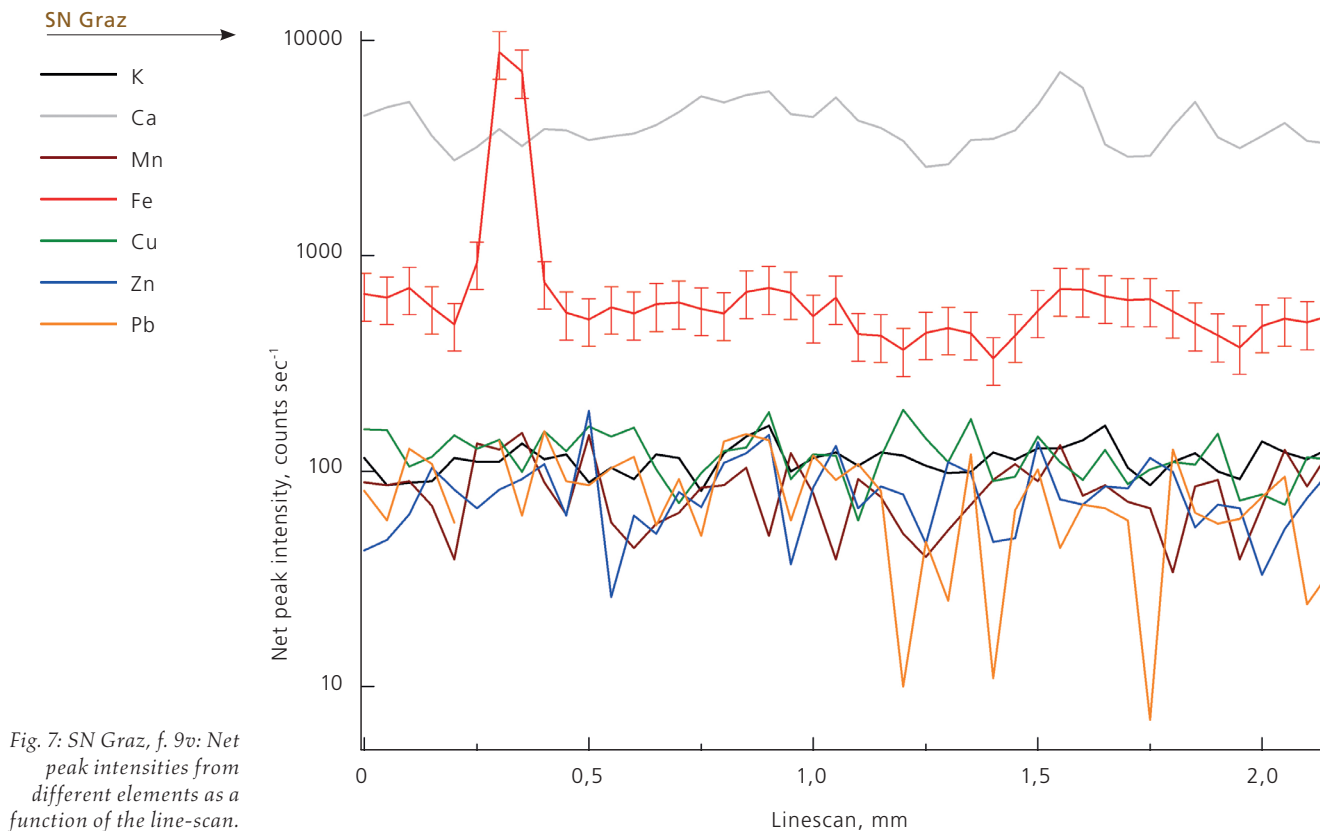


Fig. 7: SN Graz, f. 9v: Net peak intensities from different elements as a function of the line-scan.

As described above, we attempted to normalize our most recent results to the net peak intensity of iron. Again, this compilation clarifies that the relative concentration of different trace elements underlies another particular range of variation that is also visible. In comparison to the *SNML*, we found small traces of lead in the *SN Graz*.

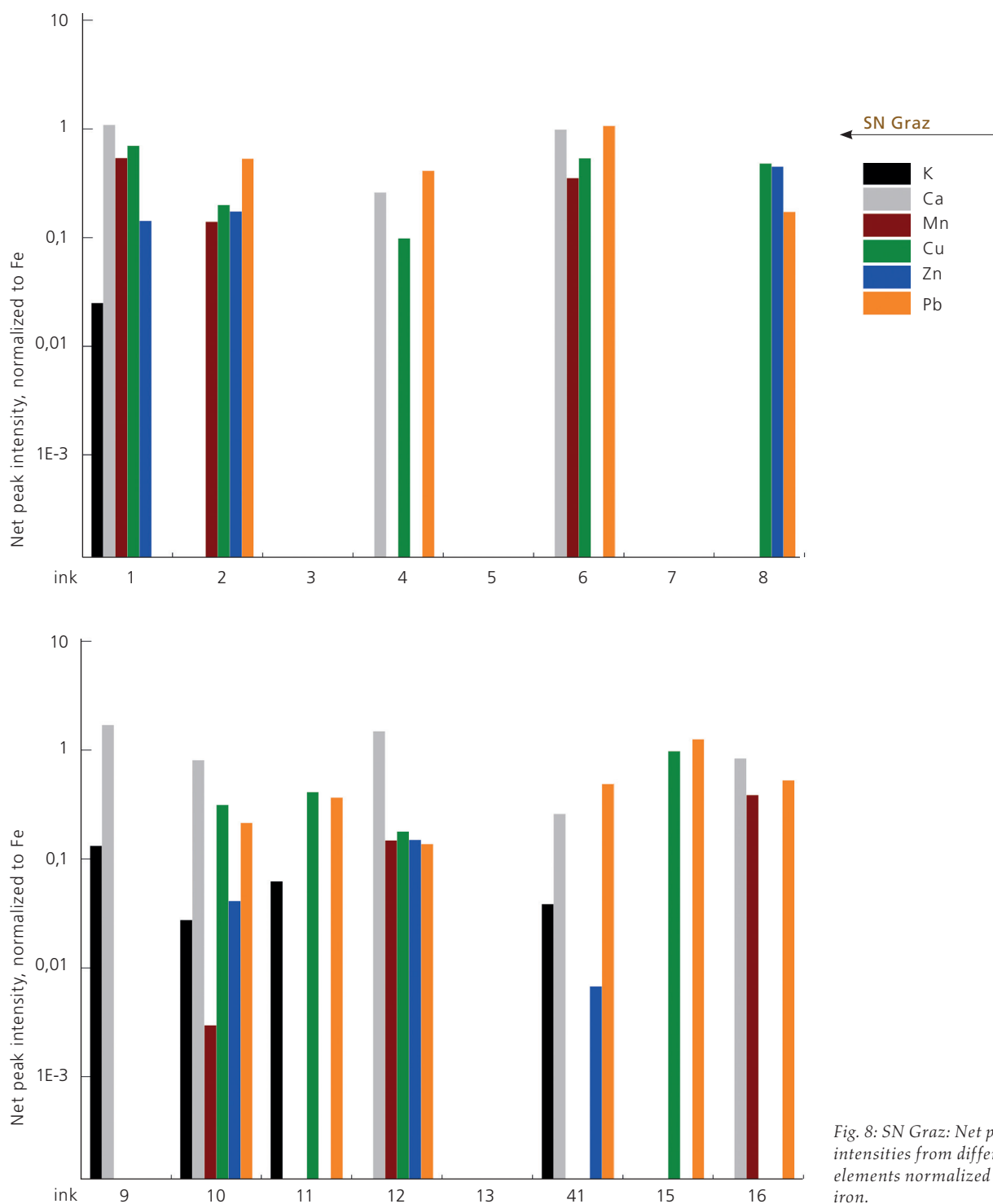


Fig. 8: *SN Graz*: Net peak intensities from different elements normalized to iron.

The paper quality

On closer consideration of figure 3 and figure 7 it is remarkable that the total amount of the elements Ca and Fe in the paper differs between the *SNML* and the *SN Graz*. It would seem that the paper of the *SN Graz* contains much more Fe and Ca than the paper of the *SNML*. Therefore we measured the trace elements in the two paper qualities at a number of different sites. The next figure shows the net peak intensities of Fe as a function of the net peak intensities of Ca. There is a sweeping difference between both papers. Taking into account that the results were not normalized to the thickness of the single paper sheets we have to conclude that the *SN Graz* paper contains much more impurities than the *SNML* paper.

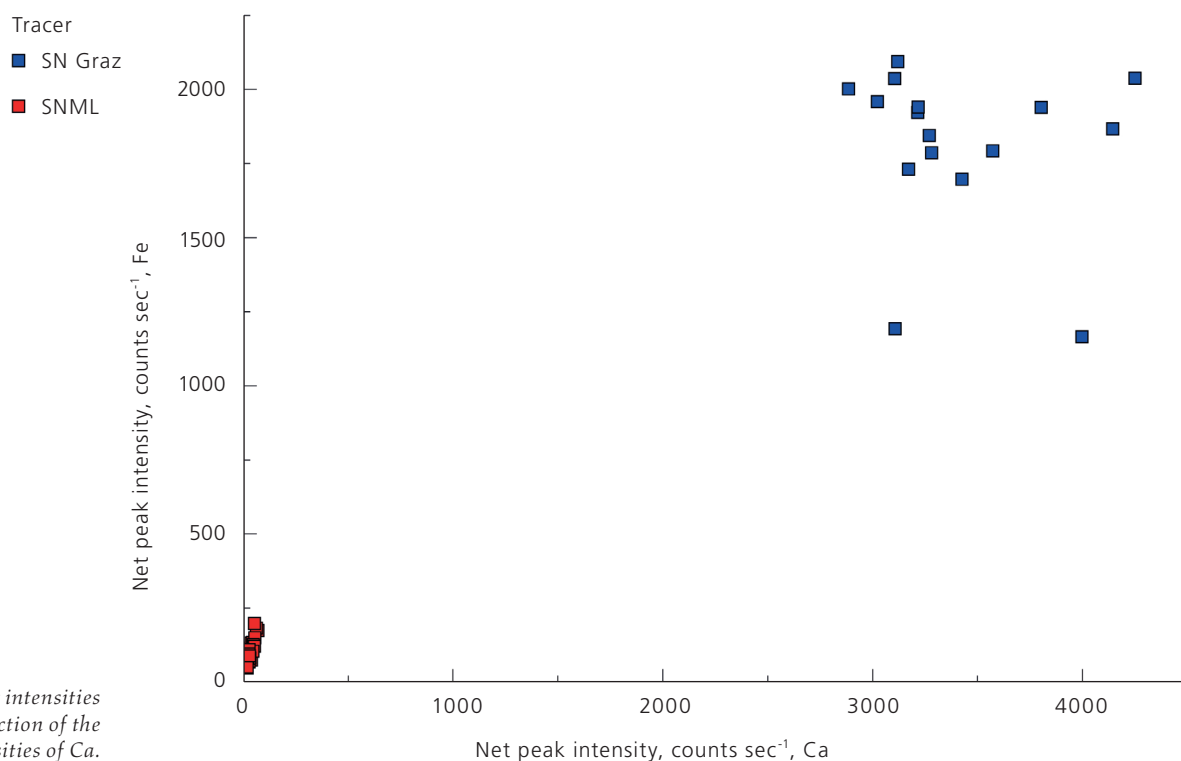


Fig. 9: Net peak intensities of Fe as a function of the net peak intensities of Ca.

The impression that the amount of trace elements may be estimated as a rough indication for the “age” of a paper is reinforced by a comparison of the SN Graz paper, the SNML paper with other paper qualities. Figure 10 shows the results of a variety of different single sheets of the 16th and the 20th century in comparison with the SNML, the SN Graz and the SNP. The net peak intensities were obtained from previous analyses.

Due to the fact that the measurements were performed under different measuring conditions (ArtTAX: 50 kV, 600 μ A, measuring spot 70 μ m diameter; Tracer: 40 kV, 300 μ A, measuring spot 4 mm diameter) it is not possible to compare the results in figures 9 and 10 directly. However, it is remarkable that paper grades of the 16th century reveal more impurities than paper grades of the 20th century. It seems that the amount of the trace elements in the SNML corresponds to the paper grades of the 20th century whereas the paper quality from the SN Graz and the SNP correspond to the paper grades of the 16th century.

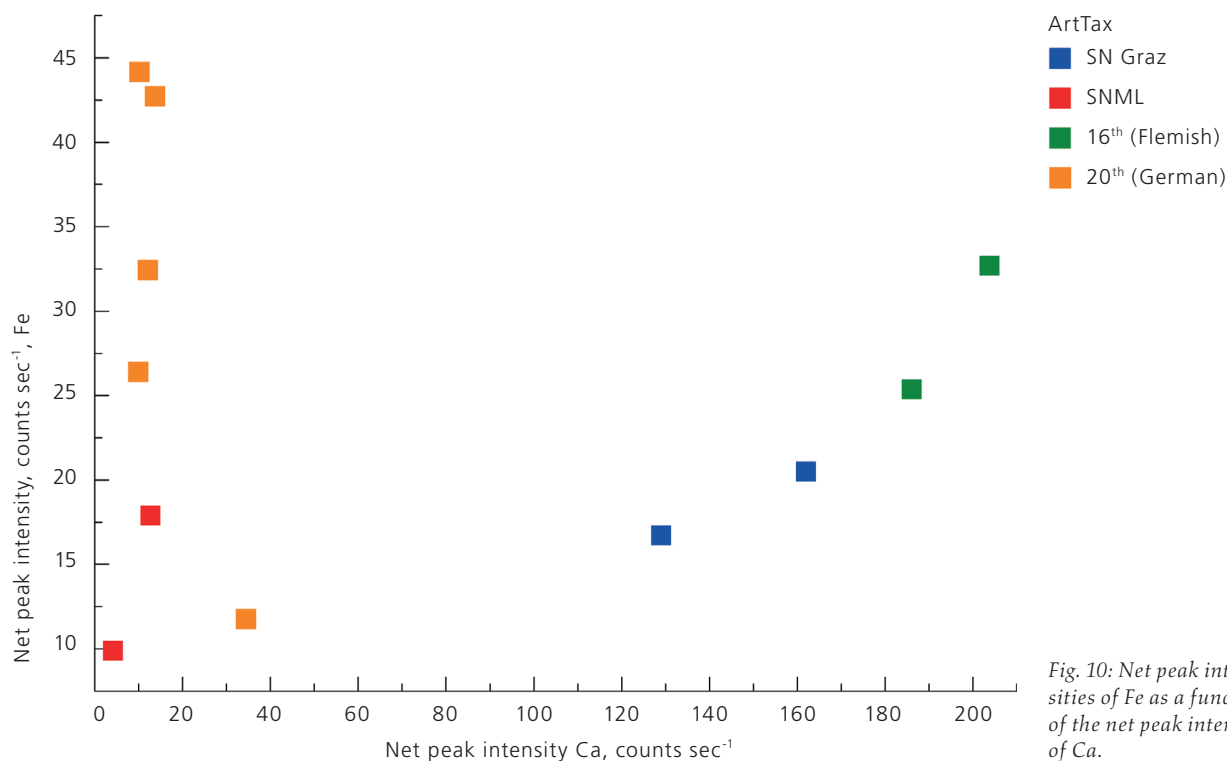


Fig. 10: Net peak intensities of Fe as a function of the net peak intensities of Ca.

KEYENCE MICROSCOPE

Using a three-dimensional microscope, we compared the indentation depths of letters and the “corresponding” line above the text.

The results reveal one distinct difference. The indentation of the print in the corresponding line in the *SNML* is much deeper than it is in the *SN Graz* (“shoulder” / “kiss”). However, one must take into account that the qualities of the respective papers in the two objects are also different. The deeper indentation of the letters in the *SNML* could be due to the fact that the paper it is made of is not glued.

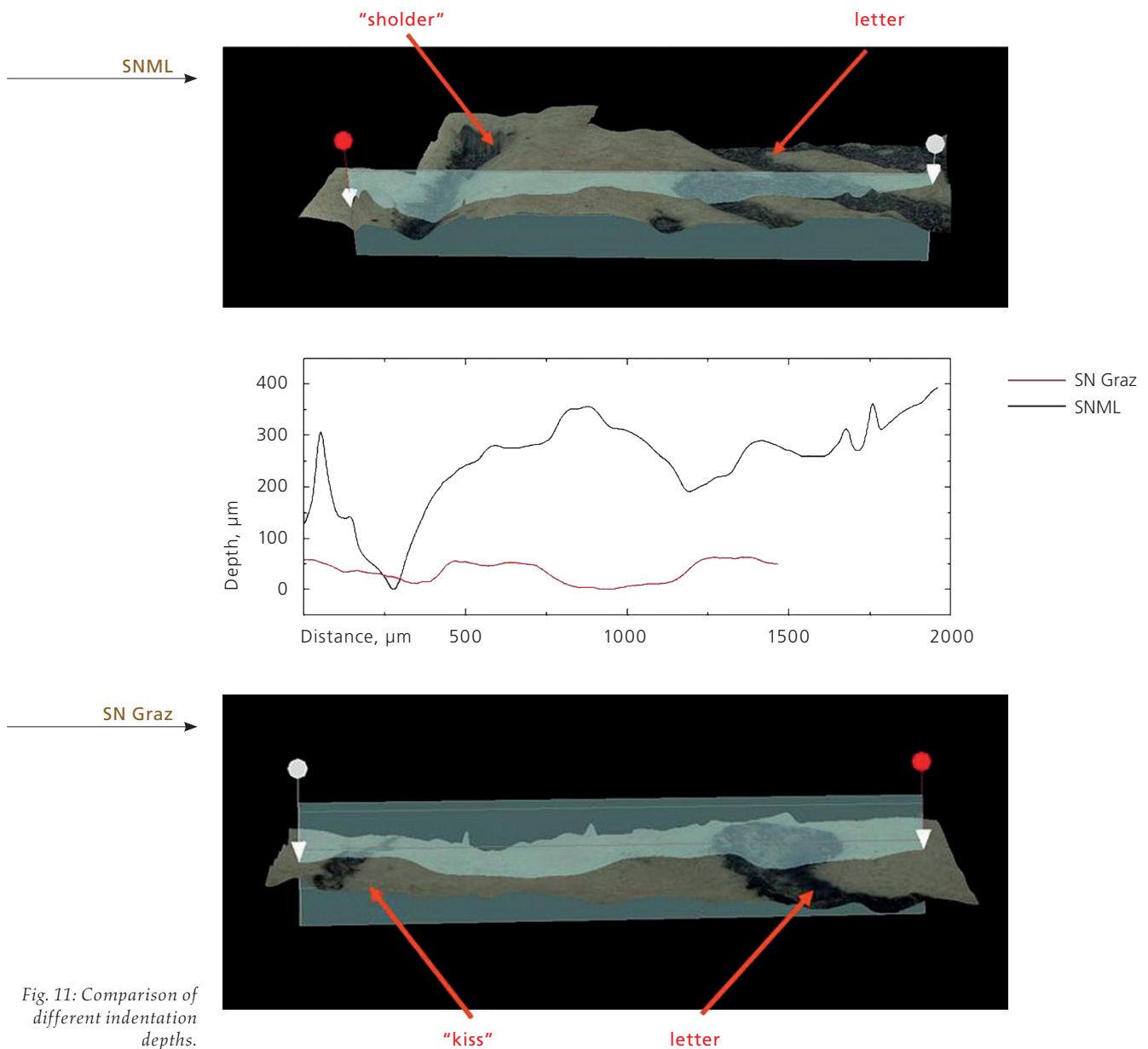


Fig. 11: Comparison of different indentation depths.

FTIR IN REFLECTION

An FTIR analysis revealed no significant differences between the paper used in the *SNML* and that used in the *SN Graz*. The spectra for both look very similar. However, both spectra reveal two interesting peaks at about 1540 and 1690 cm^{-1} indicating amid I and amid II.

The *SN Graz* paper was glued highly probable with gelatine. Therefore the presence of the characteristic amid bands is traced back to the sizing of the paper. The paper of the *SNML* was probably not glued (*see also the UV reflectography measurements in Vol. II*).

Based on the fact that the *SNML* paper was not sized we have to look for another matter which causes the presence of amid. Would it be possible that the paper contains wool fibres?

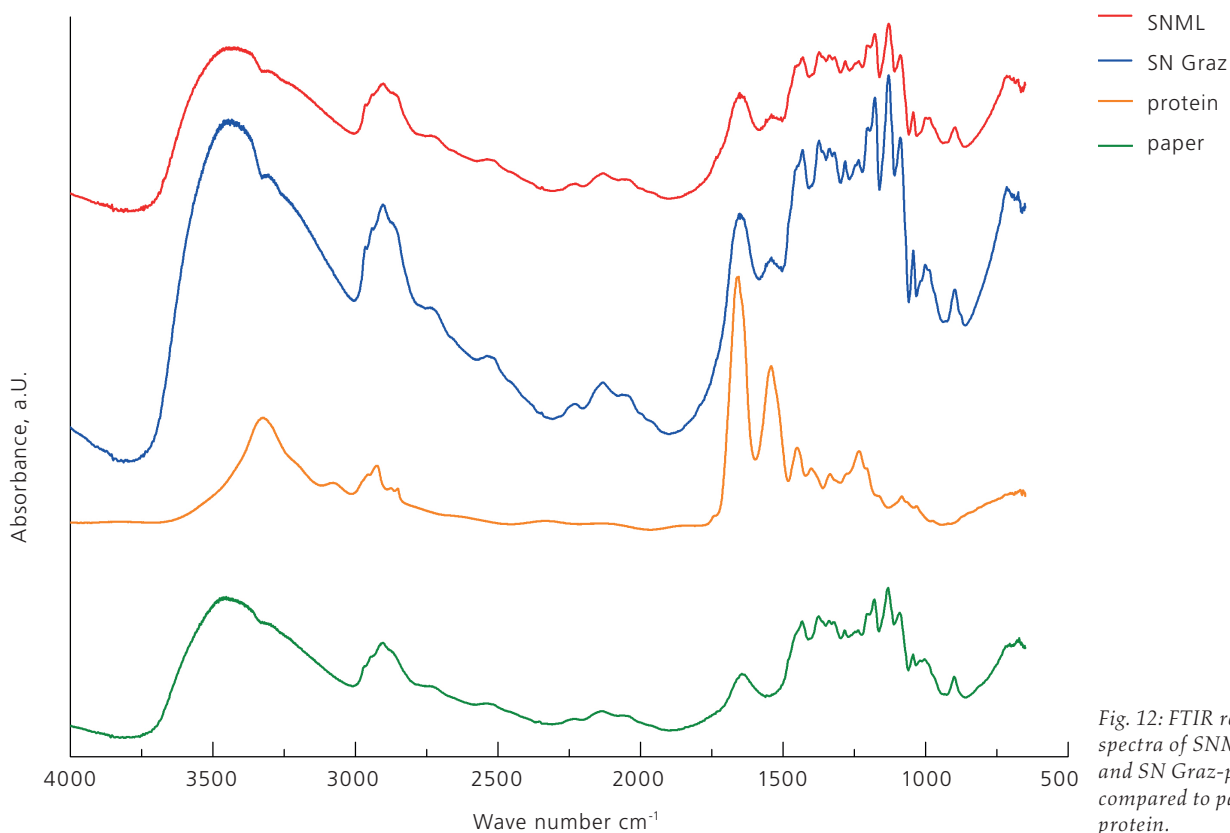


Fig. 12: FTIR reflection spectra of SNML-paper and SN Graz-paper compared to paper and protein.

GILT EDGING

In addition, we investigated the gilt edging of the entire book with XRF methods in order to compare the edging from the first pages (Sidereus) with that toward the back of the volume.

As it was not possible to carry out a quantitative analysis, we normalized the net peak intensity of different elements to gold (Au).

In the following figure, one may assume that the elements calcium (Ca), titanium (Ti) and especially iron (Fe) arise out of the red bole under the gold. The elements copper (Cu) and zinc (Zn) can be traced to the gold alloy. The various red colours result from different fading patterns.

Taking into account a margin of error and the fact that the same elements occur in both the first and in the last parts of the gilt edging, one may conclude that there is no difference between the two. The gilt edging might have been added at a later date, but this again provides no relevant proof of a falsification.

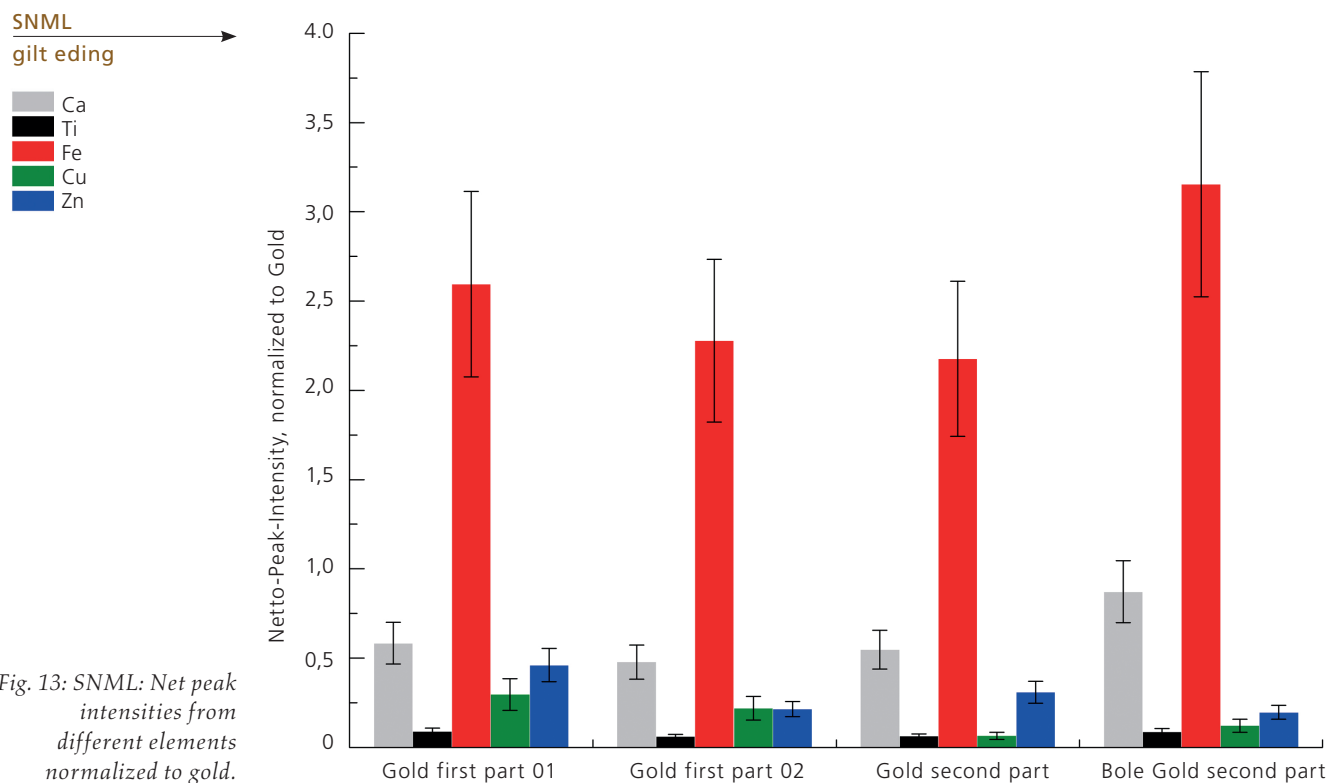


Fig. 13: SNML: Net peak intensities from different elements normalized to gold.

CONCLUSION

The non-destructive investigation of the *SNML* and its comparison to the SN Graz provided no reliable results that would prove that the *SNML* was made in the 21st century rather than in the 17th century. Nevertheless, the results raise suspicion.

The infrared spectra acquired from the different papers reveal no differences between the *SNML* and the SN Graz. This could be interpreted as evidence indicating that the *SNML* is a “hybrid”. In this scenario, the forgery would have been manufactured using original materials from the period – in this case the paper. However, the measurements carried out with X-ray fluorescence analysis revealed remarkable differences between the different papers.

The analysis of the printer’s ink using X-ray fluorescence methods show slight differences in their elemental composition; the ink used in the SN Graz contains a somewhat wider palette of trace elements. This does not constitute proof that the printer’s ink from the *SNML* was made recently. Both inks are made up almost exclusively of organic materials. A non-destructive analysis of this material – i.e., one that examines the ink’s adhesive agents and elementary carbon-containing substances – is very difficult using the methods that are currently available.

In conclusion, it is important to state that a material analysis can only unmask a forgery if the forgers make use of materials that were only produced after the date of origin of the supposed original. If historical materials from the era in question are used to make it – for example, if a forged book is printed or written on paper from the proper historic era – then it is nearly impossible from a materials sciences perspective to prove whether it is a forgery or not. This essentially applies to all available non-destructive analysis methods, which do not allow for the direct determination of an object’s age.

C-14 analysis is the only method that can provide a direct result pinpointing the age of organic materials such as paper or printer’s ink. To employ this method, however, researchers have to take samples. The amounts of material necessary for evaluation are also not insignificant, particularly when trying to date ink. Indirectly dating printer’s ink in some cases allows an examination of the adhesive agents via chromatographic methods, as amounts of corrosion products in the ink can provide insights into its age. Unfortunately, this method of analysis also requires taking samples large enough to damage the artifact significantly.

In principle, one could therefore say that it is possible to identify a “falsified” artifact beyond the shadow of doubt when non-contemporary materials have been used to make it. Acquiring convincing “verification” that an object is authentic, however, is not possible using materials analysis methods – whether destructive or non-destructive – as the forgers could also have employed materials from the proper era to create the forgery.

